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OBSERVATIONS ON THE BIOLOGY OF SOME SOUTH AFRICAN ACRIDIDAE (ORTHOPTERA)

By Julia Chesler, M.Sc.

(*Department of Zoology, University of the Witwatersrand.*)

(Communicated by Dr. B. P. Uvarov.)

[Read 1st June, 1938.]

With 27 Figures.

Introduction.

From December 1934 until January 1936 a study was made of the biology of a few species of local Acrididae in South Africa, particular attention being paid to the duration of the instars and the external morphology of the nymphs. The object of this study was to make a preliminary contribution to the knowledge of South African Acrididae and it is my intention that these studies be continued. Very few descriptions of the nymphal stages of South African Acrididae were found in the literature and it appears that there is a need for systematic descriptions on which the identification of nymphal stages can be based.

During 1935 I was enabled to pursue my studies with the aid of a University Research Scholarship from the Research Grant Board, which I wish gratefully to acknowledge. I also wish to express my sincere appreciation of the continual advice and encouragement given me by Dr. N. F. Paterson and Professor C. J. van der Horst of the Witwatersrand University. Thanks are also due to Dr. Hesse of the South African Museum for kindly identifying specimens and to Dr. B. P. Uvarov for valuable assistance in this connection.

The adult males and females and the nymphal instars of the species studied were collected chiefly in the grounds of the University, Milner Park, Johannesburg, and most of them, unless otherwise stated, were found associated in the same area.

The following is a list of the species of Acrididae collected at various times in the grounds of the University.

Acridinae (Truxalinae).

Acrida sp., *Acridella serrata* (Thb.), *Anaeolopus socius* (Stål), *Duronia chloronota* (Stål), *Cymochtha prasina* Bol., *Aiolopus thalassinus* (Fab.), *Pnorisa squalus* (Stål), *Pnorisa squalus* (St.) var. *capensis* Wlk., *Platypternodes brevipes* (St.), *Prostethophyma* sp.

Oedipodinae.

Oedaleus nigrofasciatus (de Geer), *Gastrimargus wahlbergii* (Stål), *Acrotylus patruelis* (Herr. Schäff.), *Acrotylus angulatus* St., *Trilophidia conturbata* (Walk.).

CYRTACANTHACRINAE.

Acanthacris ruficornis (F.) subsp. *fulva* Sjöst.

CATANTOPINAE.

Catantops capicolus St. var. *humeralis* Stål.

It was observed that each species appeared to have a particular type of habitat and that certain species were found in association. *Acrida* sp., *Duronia chloronota*, *Cymochtha prasina* and *Pnorisa squalus* were found in areas where the grass grew thickly about two to three feet high and where there were few open spaces. These species are all phytophilous, and were always observed on the stems and blades of grass. Only very rarely were they noticed alighting on exposed soil. *Pnorisa squalus*, which was commonest towards the end of summer, stridulates very loudly particularly during the hot mid-day hours. The wings of both *Acrida* sp. and *D. chloronota* also produce a noise when the grasshoppers are in flight. The wings of *C. prasina*, on the other hand, although appearing to vibrate very rapidly are remarkably silent and the flight resembles that of a fluttering white moth. *D. chloronota* and *C. prasina* are commonest from December to February.

Acrotylus angulatus, *A. patruelis* and *Trilophidia conturbata* are geophilous and were found frequenting open sandy areas with patches of flat grass. A number of these grasshoppers were usually found near or on heaps of red or white sand that had been deposited in the grounds. They were commonest at the beginning of the summer.

Oedaleus nigrofasciatus and *Aiolopus thalassinus* frequented sandy areas among and adjacent to patches of grass. They were commonest during the middle of the summer. *Platypternodes brevipes*, which was abundant at the end of the summer, is phytophilous and was collected on nearly every patch of grass.

Instances of parasitism were rarely met with, although red mites were particularly prevalent on *D. chloronota* and sometimes on *O. nigrofasciatus*, the other species being seemingly free of infection. Two cases of endoparasitism were noted as follows :—

Early in March 1935, a female *Acrida* sp. caught in the University grounds was dissected. It was found to be infected with about half-a-dozen parasitic dipterous larvae. They were all in the last instar but little damage appeared to have been done to the organs of the host. The dissected grasshopper was placed in a dish containing sand, and in a short while the majority of the larvae had crawled out of the grasshopper host into the soil. Within two or three days they had all passed into the pupal stage from which adults emerged, ten days later, as small black flies, specimens of which were sent to the British Museum and to Dr. Rohdendorf of Leningrad, but, as yet, no information as to their identity has been received.

Only five flies hatched out and these all died within a very short time. Numbers of grasshoppers of this and the other species studied were subsequently dissected but no further parasites were found. A few months previously another case of parasitism of an Acridid by a Sarcophagid fly had been noted.

On 13th October, 1934, several grasshoppers of the species *Phymateus morbillosus* (L.) were caught in the open veld on the farm " Riet Valley," about twelve miles from Johannesburg. Their movements were very sluggish and they flew only a few feet at a time, and only a few inches above the ground.

Two of the specimens were placed in a killing-bottle at once and three were retained alive.

In their cage the insects were markedly sluggish and on 17th October, 1934, one was found dead. The abdomen was very discoloured and the contents of one eye appeared to have been eaten away. The abdomens of the mounted specimens were also observed to be strongly darkened, but the parasites must have been killed by the cyanide.

On opening up the specimen, approximately fifty amphipneustic larvae of the Muscoid type were found in the grasshopper. The larvae were about half an inch in length and occupied the head, thorax and abdomen of the host. The fat-body, gonads and part of the intestine had been eaten away and the ganglia in the head and one eye had also been destroyed. The grasshopper was reduced practically to a case enclosing the parasites.

The larvae escaped from the grasshopper into the soil, either over the cut sides or through the membranous neck region of the host. They bored their way into the soil at once and only emerged from it, apparently in a very agitated condition, if the direct rays of the sun heated up the soil.

In the soil the larvae were quiescent, and by 19th October, all had pupated. On 1st November the first fly emerged from its reddish-brown puparium. By the following morning all the flies had hatched out. They were identified by Dr. J. Smart of the British Museum as *Blaesoxipha lineata* (Fall.).

The flies were then introduced into the cage containing the remaining live grasshoppers. Occasionally they alighted on or near a grasshopper. Sometimes the grasshopper would flick them away at once; at other times it would not react at all to the presence of the flies.

No more than two pairs of flies were observed copulating. A piece of decaying meat was placed in the cage but no larvae were deposited on it. In a short time the flies died off and by 5th November only two flies remained alive. The grasshoppers died, unparasitised, a few weeks later and thus no further particulars regarding the biology were obtained.

As far as I am aware, this is the first recorded case of a species of *Blaesoxipha* infecting *Phymateus morbillosus* (L.) in South Africa, although instances of grasshoppers and other Orthoptera parasitised by Sarcophagid larvae are very common.

It was also of interest to record that numerous webs of the spider *Argiope nigro-vittata* Thorell were observed among the grass and many grasshoppers, more particularly *C. prasina*, *D. chloronota*, *P. brevipes* and sometimes *O. nigrofasciatus*, were ensnared. On one occasion a digging wasp was noticed dragging a paralysed *P. brevipes* to its underground cell.

In the laboratory the grasshoppers were placed in wire-netting cages, fitted with drawers filled with sifted soil. A large cage measuring 28 × 20 × 18 inches was provided with a movable partition dividing it into two compartments. The smaller cages measured 16 × 11 × 10 inches and 7 × 6 × 6 inches. From two to six grasshoppers were kept in the smaller cages and up to a score in the large one. The cages were kept either in the laboratory at room temperature or in a glass-walled room the temperature of which was only slightly above that of the outside air. It was noticed that after the grasshoppers has been kept in confinement for some time they made fewer attempts to escape than when they were first placed in the cages. They were fed regularly, at least once a day, on fresh green grass and leaves and the soil in the cages was moistened from time to time. The grasshoppers ate the fresh grass voraciously and sometimes were observed nibbling at dry blades. For part of

the day the cages were exposed to direct sunlight; during this time the grasshoppers were extremely active. The temperature and humidity were not constant but varied with the conditions in the laboratory. These conditions appeared to be satisfactory and there was never any exceptional mortality.

The soil was sifted at intervals, and when the egg-pods were obtained they were placed with sifted soil in glass fruit jars which were covered with mosquito netting. In some cases loose eggs and spongy tissue were found strewn over the surface of the soil and the sides of the cage. In such cases the condition of the soil was apparently not suitable, its moisture content being perhaps incorrect or perhaps the soil was too shallow. The females of *O. nigrofasciatus*, *T. conturbata*, *A. angulatus* and *A. thalassinus* were observed ovipositing in the daytime. A female *A. ruficornis* oviposited late in the evening. In their choice of suitable sites they all appeared to avoid extremely dry parts in varying degrees; *A. angulatus* and *A. thalassinus* eggs were found in almost dry soil whereas *A. ruficornis* and *O. nigrofasciatus* females chose the parts of the cage where the soil was definitely moist.

After removal from the cages the soil containing the eggs was thoroughly moistened, and again from time to time as the soil became dry. The jars containing the eggs were kept in the laboratory and thermometers placed in the soil registered temperatures ranging from about 19° C. to 44° C., the lower temperatures being recorded in the mornings and the higher temperatures being reached after the jars had been exposed to the afternoon sunlight for a few hours. On some occasions, when the weather was colder, the jars were placed on a moderately heated oven for the night. Some jars were kept continuously in an incubator at a temperature of about 30° C. with satisfactory results.

When the nymphs emerged they were placed in glass jars containing moistened soil and grass and with mosquito netting over the top. It was noticed that the approach of storms and rain very often coincided with the actual hatching of nymphs. Immediately on emerging the nymphs hopped about actively and after a short period they showed a tendency to feed.

In some cases, numbers of young nymphs died a day or two after emerging from the eggs. After this initial mortality there was no further mortality among the surviving nymphs. There was no apparent reason for this phenomenon, for in *A. angulatus*, *T. conturbata* and *O. nigrofasciatus*, in which the older hoppers thrived under laboratory conditions, large numbers of the first-stage nymphs succumbed.

It was, however, observed that fewer first-stage nymphs died if they were supplied with grass torn into fine shreds, the edges of which were thin and uneven, so that in all probability the high mortality observed in some species was due to the inability of the young nymphs to feed on the coarser uncut grass.

The nymphs were fed regularly on grass and leaves and occasionally lettuce and sliced apples. For some time the grasshoppers were fed on lettuce alone, as this remained fresh for a longer period than blades of grass. Hodge (1933), however, in a study of the growth and nutrition of *Melanoplus differentialis* (Thomas), indicated that a restricted diet such as lettuce was unsatisfactory and led to relatively poorer development, irregular growth, susceptibility to pathological conditions and higher mortality of the insects. The pure lettuce diet was, therefore, discontinued and the grasshoppers were fed on a mixture of leaves, grass and lettuce, and occasionally on sliced apples, and this mixed diet proved quite satisfactory. Occasionally when insufficient food had been supplied some grasshoppers were found to have been attacked and eaten by their fellows.

Numbers of nymphs were also collected at various times after the rainy season had set in, and were placed in glass jars, where they were fed and kept under observation. The nymphs fed and moulted quite readily in captivity, and a number, caught in the early instars, were reared to the adult stage.

The nymphs that died were preserved by placing them in hot 40% alcohol and then transferring them to 70% or 80% alcohol. In all cases the colours of the preserved nymphs faded after some time. The morphological descriptions are, however, based chiefly on these preserved specimens supplemented by observations on the coloration of living grasshoppers. Careful records of the duration of the different instars were kept. The measurements were taken by sliding callipers from the base to the tip of the antennae, dorsally from the vertex to the extremity of the abdomen, and dorsally from the coxal to the knee joint of the hind femur. Measurements of the length and the width of the tegminal and wing rudiments were also recorded. A cursory examination of the external development of the tympanal organ was made. In all the species there was no evidence of the organ in the first instar, but in the succeeding instars the gradual growth of the organ could be traced from the first evidence of the enlarged spiracle in the second and third instars to the appearance of the membrane, its sinking inwards and the thickening of the ridge surrounding it, in the fourth and later instars.

Of the list of species given on pages 313–314, the biology of the following was studied in some detail: *Acrida* sp., *Acanthacris ruficornis* F. subsp. *fulva* Sjöst., *Trilophidia conturbata* (Walk.), *Acrotylus angulatus* St., *Oedaleus nigrofasciatus* (de Geer), *Aiolopus thalassinus* (Fab.).

Acrida sp. (figs. 1–5).

Acrida sp. was fairly common in the University grounds, Milner Park, Johannesburg, throughout the summer. It is phytophilous and its green and brown coloration harmonises with the long grasses among which it is found. It is less common than the smaller species of ACRIDIDAE found in the same area. The long thin bodies and slender legs of the nymphs closely resemble the stalks and blades of grass to which they cling. The older nymphs are bulkier and more clumsy in their movements. The adults are good fliers, and the flight of the males is accompanied by a whirring noise. They are somewhat conspicuous when in flight on account of their yellow wings. The females are much larger than the males and pass through an additional instar during their development. Eggs were obtained from grasshoppers in the laboratory from January onwards and nymphs emerged in April. The number was supplemented by nymphs collected in the field and many were bred through to the adult stage. Both nymphs and adults were fed on grass which they appeared to relish and which constitutes their natural food source in the field.

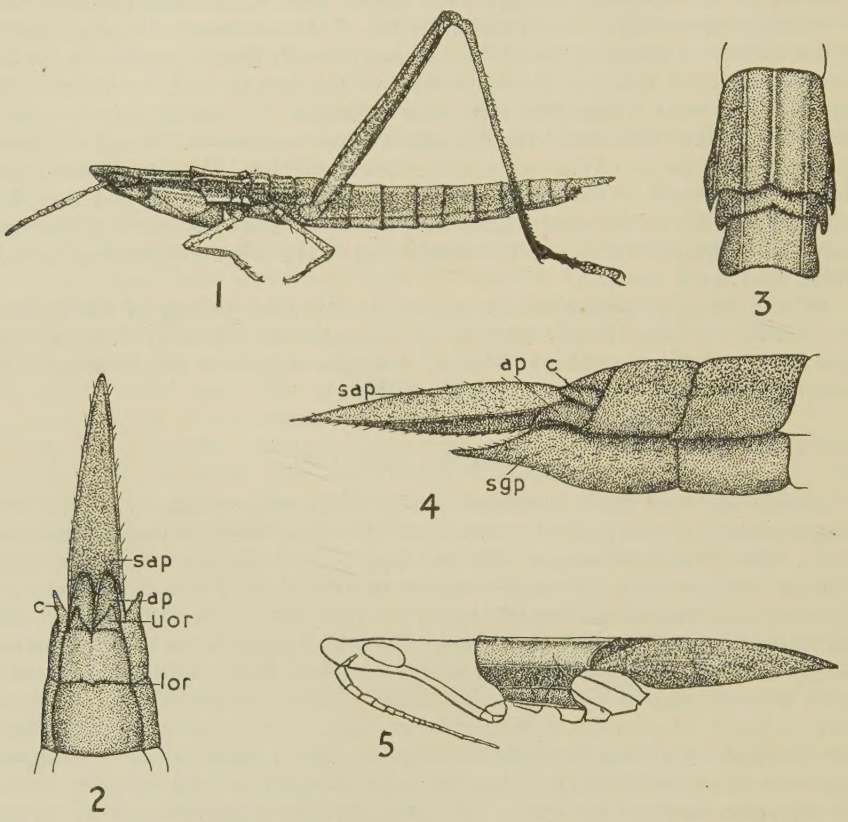
From September onwards hoppers were numerous; in January adults were observed in the field. The adults in the laboratory remained alive throughout the winter months. Oviposition was observed from January onwards until April.

The large egg-pod is curved and measures 65 mm. in length and 10 mm. across. At the bottom it narrows down to 7 mm. The eggs, of which there are about forty-five in a pod, are enclosed in spongy tissue to which soil particles adhere, forming part of the wall of the pod. The diagonally arranged eggs are very closely packed in the pod. They are long, narrow, curved in shape and brown in colour. The egg measurements are 7·5 mm. by 1–1·5 mm.

First-stage Nymph (fig. 1).

General coloration and appearance.

The hoppers are thin with slender bodies, the hind legs being particularly long and thin. They are green in colour with darker green or brown longitudinal cephalic and thoracic bands. The dark brown eyes at the side of the head are dorso-ventrally elongate. The distal portions of the tibiae and tarsi are black or dark brown in colour and are in marked contrast with the lighter colouring of the rest of the body. This differentiation in the colour of the distal part of



Figs. 1–5.—*Acrida* sp. nymphs. 1, first stage; 2, second stage ♀, ventral view of terminal abdominal segments; 3, second stage ♀, dorsal view of thorax; 4, fifth stage ♂, lateral view of terminal abdominal segments; 5, seventh stage ♀ (Explanation of lettering—*ap*, anal plate, or periproct; *c*, cercus; *lor*, lower valve of the ovipositor; *sap*, supra-anal plate, or epiproct; *sgp*, subgenital plate; *uor*, upper valve of the ovipositor).

the hind legs was also observed in the first-stage nymphs of the other species studied. Hairs are sparsely distributed over the body and legs.

Head. The frons is sharply deflected and lies entirely sub-ventrally on the elongate, conically shaped head. The vertex extends forward to a short blunt fastigium in front of the eyes. The flat leaf-shaped or ensiform antennae are attached ventrally. They are light brown in colour and are composed of nine to eleven segments. On each side of the head from behind the eyes there extends a dark green band which is marked off by light-coloured stripes on the

head and thorax but is not clearly demarcated along the sides of the abdomen. *Thorax.* The anterior margin of the pronotum is curved and the posterior margin is incised in the mid-line and laterally. A median brown carina extends down the length of the pronotum. In line with the carina there is a light brown stripe along the mid-line of the meso- and metanotum. On each side of and parallel to this median carina is another light coloured carina extending for the length of the pronotum. Half-way down the pronotum a transverse furrow extends on each side from the lateral carina to the edge of the pronotum. Distal to this another transverse furrow extends right across the pronotum. A prominent dark reddish-brown stripe outlines the edge of the pronotum. The pronotum partly overhangs the mesonotum. The tegminal and wing rudiments are foreshadowed by the rounded and slightly produced edges of the meso- and metanotum respectively. The first two pairs of legs are short and thin. The femora and tibiae of the hind legs are long and slender. Numerous minute spinules are arranged regularly on the tibiae of all the legs. Cerci are present and the supra-anal plate is produced into a pointed, dagger-shaped process on which hairs are regularly distributed. A similar enlarged supra-anal plate is figured for *Betiscoides meridionalis* Sjöst. by Key (1930).

Measurements.

Antennae	2–2·5 mm.
Body length.	9·5–11 mm.
Hind femur	5 mm.

Second-stage Nymph (figs. 2 and 3).

The general appearance is similar to the first stage. The brown markings and stripes may be more sharply defined than in the previous stage. The antennae are composed of eleven to fourteen segments. The lateral margins of the meso- and metanotum are extended and produced into tegminal and wing rudiments. The last abdominal sternite and the subgenital plate are modified to form the rudiments of the ovipositor valves, in the female. The prolongation of the supra-anal plate is relatively longer than in the previous stage. From above, the sides of this prolongation slope away from the median ridge, like the sloping roof of a house.

Measurements.

Antennae	3 mm.
Body length. . . .	12–18·5 mm. (end of instar)
Hind femur	6·5 mm.

Third-stage Nymph.

The nymphs are now bulkier in appearance and the hind femur is thicker and relatively better developed than in the previous stages. The males are shorter and thinner than the females. The colouring varies from green to greyish or brownish-green. The stripes and contrasts in colouring are more pronounced than in the earlier stages. The antennae are composed of eighteen or nineteen segments. The whole of the head, particularly the sides and lower surface, is covered with longitudinal yellowish-white, regularly arranged, fine lines and markings. Lines similar to those on the head enclose a darker coloured mottled band on each side of the pronotum between the lateral carinae and the edge. This band extends from the head down the sides of the thorax and

abdomen. The lower binding stripe extends from behind the eye along the edge of the thorax and continues on to the episternum of the metathorax. Fine diagonal stripes are found on the mes-epimeron and -episternum.

The narrow tegminal rudiment lies beside the metanotum, the lateral prolongation of which is broad and triangular in shape. The valves of the ovipositors are developed in the female, and the prolongation of the supra-anal plate has increased in size absolutely, although in all the instars its length relative to the body remains constant.

Measurements.

Antennae	5 mm.	
Body length	♂ 19·5 mm.	♀ 18–23·5 mm. (end of instar)
Hind femur	9·5 mm.	8·5–9·5 mm.

Fourth-stage Nymph.

There is a noticeable increase in the size of the body and hind legs in this instar, although the ratio of the length of hind leg to length of body is slightly less than that of the previous instar. The colouring varies from green to greenish-brown, reddish-brown and brownish-grey. Some hoppers have a pinkish tinge and grey and black stripes with beige to light-brown wing rudiments. The antennae are composed of twenty or twenty-one segments. The pronounced curves of the pronotum result in acute antero- and postero-lateral angles. The narrow tegminal rudiments and the triangular wing rudiments are only slightly larger than in the previous instar. The dorsal and ventral valves of the ovipositors are differentiated. Dark coloured stripes extend down the legs which are patterned with mottled markings. Dark brown dots are arranged at regular intervals along the edges of the hind femora which are thicker than in previous stages.

Measurements.

Antennae	6·5 mm.	
Body length	♂ 25 mm.	♀ 24–30·5 mm.
Hind femur	10·5 mm.	11 mm.
Tegminal rudiments, length	1·5 mm.	1·5 mm.
width	0·5 mm.	0·5 mm.
Wing rudiments, length	1·5 mm.	1·5 mm.
width	0·5 mm.	0·5 mm.

Fifth-stage Nymph.

The hoppers may be green, brown or greyish with yellowish-white or pinkish contrasting stripes. The wing rudiments are green or yellowish-green and the abdomen is usually a shade of grey. A hopper which had been kept in a blue coloured glass jar for some time appeared to have been affected by this as it was grey, with a distinct blue tinge. The antennae are composed of twenty-one to twenty-three segments. Up to and including the fourth instar the development of the male and female hoppers is the same. After the fourth instar a difference in the development of the male and female is apparent, the female passing through an additional instar in which the size of the nymph is increased, while the development of the tegminal and wing rudiments is only slightly in advance of that of the previous instar. The fifth female instar represents the extra female instar, the sixth and seventh female instars

corresponding to the fifth and sixth male instars as regards appearance and the development of the tegminal and wing rudiments.

Fifth-stage Male Nymphs (fig. 4).

These are much smaller than the females. The wing rudiments, which extend to the second abdominal segment, are turned back dorsally and cover the distal portion of the tegminal rudiments. The wing rudiments do not touch mid-dorsally.

Measurements.

Antennae	8·5–9·5 mm.
Body length	29–34 mm.
Hind femur	13–16·5 mm.
Tegminal rudiments, length	4 mm.
width	0·5 mm.
Wing rudiments, length	3 mm.
width	1 mm.

Sixth-stage Male Nymphs.

The distal extremity of the narrow tegminal rudiments project from under the triangular-shaped wing rudiments which meet in the mid-line and extend to the third abdominal segment. The tympanum appears to be fully developed. The membrane is transparent, the ridges and border fully formed and the tympanal bodies can be discerned. The genital appendages are completely formed and the prolongation of the supra-anal plate measures 4 mm.

Measurements.

Antennae	11–12 mm.
Body length	37–40 mm.
Hind femur	18–19 mm.
Tegminal rudiments, length	9 mm.
width	1 mm.
Wing rudiments, length	7 mm.
width	2 mm.

Fifth-stage Female Nymphs.

The narrow, pointed wing rudiments, which are sharply demarcated from the metanotum, extend to the posterior border of the first abdominal segment. The narrow pointed tegminal rudiments extend at the sides of the wing rudiments to the posterior border of the metanotum.

Measurements.

Antennae	10·5–11 mm.
Body length	32–38 mm.
Hind femur	13·5–17 mm.
Tegminal rudiments, length	2 mm.
width	0·5 mm.
Wing rudiments, length	2·5 mm.
width	0·5 mm.

Sixth-stage Female Nymphs.

The erect wing rudiments extend to the second abdominal segment and cover the tegminal rudiments. The genital appendages are completely formed and the prolongation of the supra-anal plate measures 5 mm.

Measurements.

Antennae	14·5 mm.
Body length	40–51 mm.
Hind femur	21·5 mm.
Tegminal rudiments, length	6 mm.
width	1·5 mm.
Wing rudiments, length	6 mm.
width	2 mm.

Seventh-stage Female Nymphs (fig. 5).

The narrow tegminal rudiments extending to the third abdominal segment are slightly longer than the wing rudiments (fig. 5). The supra-anal plate measures 6 mm. in length.

Measurements.

Antennae	15 mm.
Body length	52–58 mm.
Hind femur	23·5 mm.
Tegminal rudiments, length	13·5 mm.
width	1·5 mm.
Wing rudiments, length	10 mm.
width	3 mm.

In the last two instars the contrasting stripes and colours are conspicuous and are identical with the characteristic coloration and pattern of the adults. The colour of the hoppers varies, but green is predominant. The green hoppers were more numerous than the brown specimens with reddish stripes and a rose or pinkish tinge. The tegminal rudiments are green or yellowish, and the abdomen grey and the ventral surface pale green. The antennae, composed of twenty-three or twenty-four segments, show an increase in size and length, compared with previous instars, but not in the number of segments.

Duration of Instars and Number of Generations.

There are six nymphal instars in the male development and seven in the female, the additional instar being probably due to the disparate sizes of male and female. A total of approximately 145 nymphs of this species was dealt with.

The duration of the instars is tabulated below:—

Instar	Duration in days		Average duration in days	
	♂	♀	♂	♀
1st	15–26		20	
2nd	13–28 (37)	14–17	22	16
3rd	14–25 (44)	20–25 (32)	21	22
4th	15–28	17–28	22	22
5th	17–25 (32)	18–24	21	22
6th	19–28 (52)	25–40	27	29
7th (♀♀ only)	—	21–44	—	27

Average total duration, ♂ . . 133 days.
♀ . . 158 days.

The numbers in brackets refer to specimens in which the duration of the instar was exceptionally long.

There is one generation a year. The eggs are laid towards the end of summer from January to March and April. After development of a few weeks in the egg-pod the nymphs emerge during the autumn months from April onwards. The winter is passed through in the young hopper stages and in September, October and November, numerous second-, third- and fourth-stage nymphs occur in the field. Adults appear in December and are common until March and April, after which they are not very common. Some adults were kept alive during the winter in the laboratory.

Acanthacris ruficornis F. subsp. *fulva* Sjöst.

A number of these large grasshoppers was collected on thorn and other bushes at Brits, Transvaal, as well as on bushes of *Salvia* sp., wild currant and other shrubs in gardens in Johannesburg and district, during the months of January to April.

It is a strong flier and the adults are consequently difficult to catch. In northern Transvaal, where they are fairly common, these grasshoppers are captured and eaten by the natives. The newly moulted adults are grey in colour, but as they approach maturity, the males particularly, become a vivid green. The grey and green colouring of the adults harmonises very well with the foliage of the bushes on which they are found. The green coloration and rugose appearance of the hoppers also blends with the leaves of the shrubs and bushes on which they feed. During development the bright green of the young hoppers changes to an olive-green colour in the later stages and finally becomes a mottled grey or brown tinged with dark green. In a few 7th instar nymphs, the brown pronotal bands which are characteristic of the adult become noticeable. They are voracious eaters and in the laboratory they were successfully reared on various kinds of leaves. A preference was, however, shown for the leaves of perennial mesophytes such as *Malva verticillata*, *Salvia* sp. and other garden shrubs on which the hoppers and adults were collected. Leaves of *Sida rhombifolia*, geranium and shasta daisy leaves and stems were also readily attacked. In addition the grasshoppers ate potato, plum, apricot, oak and snapdragon leaves and pieces of apple.

An experiment was performed in order to determine the relative increase in weight during development as compared with the quantity of food eaten. For this experiment four lots of specimens were kept under observation. Lots A and B were 3rd instar nymphs of *Acanthacris*, lot C was in the 5th instar, while lot D was first-stage nymphs of *Platypternodes brevipes*. At the beginning of the experiment the weight of each specimen was obtained. Each was then fed daily with a known weight of geranium, shasta daisy or *Sida rhombifolia* leaves. As a control in each case the same quantity of leaves was set aside in order to determine the loss of weight due to evaporation. In this way it was possible to estimate the quantity of food eaten by the hoppers.

In the case of the first-stage nymphs of *P. brevipes*, owing to the small size and weight of the hoppers, it was thought advisable to deal with them together, instead of individually, in order to avoid involving too large an error in the calculations. The nine hoppers were weighed together and kept in the same jar, and the readings refer to the total weight of all the specimens. During the course of the experiment the number of hoppers was reduced from the original nine to five, due to some hoppers escaping from the jar and some dying.

Although the material handled was insufficient to enable accurate conclusions to be drawn, it will nevertheless serve as a preliminary guide to a more

intensive quantitative survey of the relation between various kinds of diets and growth in insects and a possible correlation with nutritional studies in other classes.

The experiment may be summarised in tabular form as follows :—

Lot :	A	B	C	D
Diet :	Geranium	Shasta Daisy then *Sida rhombifolia*	Shasta Daisy then grass	Grass
Initial weight in grammes .	0·37	0·34	1·25	$\frac{0·13}{9}$, *i.e.* 0·01–0·02
Final weight in grammes .	0·71	0·20	1·22	$\frac{0·13}{5}$, *i.e.* 0·03
Interval in days . . .	21	16	6	44
Increment in weight in grammes . . .	0·34	−0·14	−0·03	0·06
Percentage increment of initial weight . . .	92	−41	−2	86
Average increment in weight per day in grammes . .	0·02	−0·01	−0·005	<0·01
Total weight eaten in grammes . . .	2·0	1·4	1·1	0·7
Average weight eaten per day in grammes . . .	0·01	0·02	0·2	<0·01

During the observations B moulted after five average daily losses of weight of 0·01 g. and then died after eleven days of the same average daily loss of weight. The exuvium weighed 0·01 g. Lot C lost 0·07 g. or 5% of its previous weight after one day on a grass diet. Lot D moulted into the second instar, the exuvia weighing less than 0·01 g.

The conditions under which the above weights were recorded were not sufficiently uniform and balanced to justify comparisons of any value being made. One would, however, expect a gradual increase in weight concomitant with the increase in size. Only lots A and D showed this increment; one factor which probably accounted for the loss of weight in B and C, being the change of diet.

Adults kept in the laboratory copulated during March and April, and the eggs which were subsequently deposited underwent a winter diapause in the soil at the bottom of the cage, which was kept on a concrete bench in a room on the roof of the building. The soil in the cage was left undisturbed and unattended from the time the last adult died. Early in December about fifty active bright green hoppers emerged. At the same time young hoppers were also found on shrubs in the University grounds. In February fourth- and fifth-stage nymphs were observed in the open, while those reared in captivity had passed into their fourth or fifth instars as well, and a few others had reached the sixth instar. Some of these hoppers collected in gardens were of a paler and more uniform green than the laboratory specimens. Such variations are probably due to some environmental difference.

The majority of the hoppers in the laboratory were bred through to the final stage and adults were obtained from March onwards. Their development, therefore, takes at least four months to reach completion. Pairing, which was

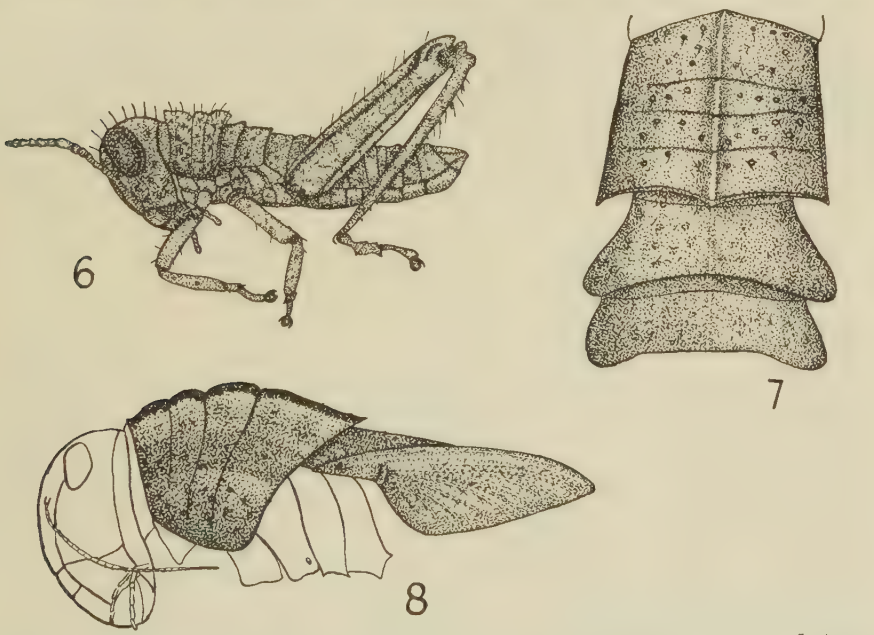
observed in April, usually lasted for a few hours. One pair was observed mating with the female suspended on the wire netting at the side of the cage. Late on an April afternoon, after some showers of rain, a female was observed ovipositing in the middle of an exposed lawn and the egg-laying in this instance lasted for a few hours. The top of the long, rather wide egg-pod was on a level with the surface of the soil, and the egg-pod measured 65 mm. × 10 mm. wide. At the upper end of the egg-pod there is a plug of spongy material. Soon after they are laid the eggs turn brown. They are covered with a flaky chorion and are held together by a thin layer of spongy tissue. Some pods are slightly curved. At the lower end the covering is so thin that the eggs are in direct contact with the soil. There are from 70 to 130 eggs in a pod, each measuring 6·5 mm. by 1·5 mm. Some adults were kept in the laboratory throughout the winter until September, when most of them died off.

Specimens preserved in alcohol soon lose their characteristic bright green colour, becoming reddish-brown and eventually almost colourless.

First-stage Nymph (fig. 6).

General appearance and coloration.

The cuticle of these very active hoppers is green and rugose, closely resembling in appearance the surface of the leaves on which they feed. Small dark



Figs. 6–8.—*Acanthacris ruficornis fulva* (Sjöst.), nymphs. 6, first stage; 7, second stage, dorsal view of thorax; 8, seventh stage ♀.

green dots ringed with black are regularly distributed over the body and are particularly numerous on the legs. This spotted appearance adds to their resemblance to the surface and texture of a leaf.

Head.—At the beginning of the instar the head is large in comparison with the rest of the body, but after a few days the abdomen begins to increase

appreciably in size. The fairly conspicuous lateral eyes are dark brown with a lighter brown margin. The thickish, filiform, antero-ventrally placed antennae are somewhat clavate distally and are composed of thirteen segments. The tip is darker in colour than the basal segments. There are transverse dark bands on the maxillary and labial palps. *Thorax.* The continuity of the median keel on the well-developed pronotum is interrupted by transverse furrows. The posterior margin is slightly incised in the mid-line and is wider than the anterior margin. In profile the anterior margin is oblique and the pronotum is longer in the mid-line than along its lateral edge. The pronotum overhangs the mesonotum, the lateral edges of which, and likewise those of the metanotum, are rounded. The spines and claws of the legs, which are covered with dark dots, are black or tipped with black. The cerci and ovipositor rudiments at the end of the abdomen are well developed.

Measurements.

Antennae	2 mm.
Body length	5·5–7 mm.
Hind femur	4 mm.

Second-stage Nymph (fig. 7).

The general appearance and coloration does not differ very markedly from the first instar except that the green colour is less vivid.

The antennae are composed of fifteen segments. The depressions in the median keel of the pronotum due to the transverse furrows are more marked than previously (fig. 8). The anterior margin of the pronotum overhangs the occiput. The mesonotum is almost covered by the pronotum and the lateral margins of the metanotum are produced into rounded extensions foreshadowing the wings.

Measurements.

Antennae	2·5 mm.
Body length	7·5 mm.
Hind femur	5 mm.

Third-stage Nymph.

The leaf-green coloration of previous instars is, in this instar, replaced by a somewhat olive-green coloration. The eyes are longitudinally striped with light and dark green bands. Conspicuous white spots are regularly arranged on the pronotum which is of a darker green mid-dorsally along the median keel.

The antennae, which appear to be less clavate than in earlier instars, are composed of nineteen or twenty segments. The median keel of the pronotum is well developed and deeply furrowed by three transverse grooves. The tegminal and wing rudiments are now differentiated and are lighter in colour than the rest of the meso- and metathorax.

A semicircular ridge and a well-developed stigma define the incipient tympanal area. Both pairs of ovipositor valves are formed in the female, and the genital plate of the male is differentiated.

Measurements.

Antennae	4 mm.	
Body length	♂ 14·5 mm. (end of instar)	♀ 16·5 mm.
Hind femur	6 mm.	

Fourth-stage Nymph.

These hoppers are olive-green with white markings on the pronotum and conspicuous black dots along the median keel. Hoppers collected from gardens were of a paler and more uniform green than those bred in the laboratory.

The antennae are composed of twenty-two or twenty-three segments, the terminal ones being of an almost uniform width. The tegminal rudiments extend to about half the length of the metathorax. The triangular wing rudiments are separated by a slight ridge from the metathorax. The tympanal membrane is well differentiated and almost transparent.

Measurements.

Antennae	5 mm.
Body length	♂ 14·5 mm. ♀ 15·5 mm. (beginning of instar)
Hind femur	7·5 mm.
Tegminal rudiments, length	2 mm.
width	1 mm.
Wing rudiments, length	2 mm.
width	1 mm.

Fifth-stage Nymph.

The hoppers, which are mottled pale and olive-green in colour, with light fawnish markings and black spots, are now bulky in appearance, and sexual dimorphism is apparent in the larger size of the females. The antennae are composed of twenty-four or twenty-five segments. The pronotum overhangs the mesonotum. The narrow finger-shaped tegminal rudiments just cover the proximal portion of the broader triangular wing rudiments.

Measurements.

	♂	♀ (beginning of instar)	♀ (end of instar)
Antennae	6·5 mm.	6·5 mm.	7 mm.
Body length	17·5 mm.	15·5–16 mm.	27·5 mm.
Hind femur	10 mm.	10 mm.	11·5 mm.
Tegminal rudiments, length	2·5 mm.		
width	1 mm.		
Wing rudiments, length	2 mm.		
width	2 mm.		

Sixth-stage Nymph.

Light greenish-grey patches are distributed over the olive-green ground-colour and are most obvious on the thorax. Some hoppers have fawnish spots distributed over the body surface. Dark green or black spots are particularly numerous on the hind legs and along the mid-line of the pronotum.

The antennae are composed of twenty-seven or twenty-eight segments in the female and twenty-five in the male. The posterior margin of the pronotum extends backward to overhang the proximal portion of the triangular, pointed wing-rudiments, which are folded backward and upward and reach to the second abdominal segment where their distal tips touch in the mid-line.

The finger-shaped tegminal rudiments extend as far as the proximal margin of the first abdominal segment and are covered by the pronotum and wing rudiments. Longitudinal veins are apparent on the rudiments. The tympanal membrane is transparent.

Measurements.

	♂	♀
Antennae	8 mm.	10 mm.
Body length	21 mm.	25 mm. (beginning of instar)
Hind femur	12 mm.	15 mm.
Tegminal rudiments, length	5 mm.	5·5 mm.
width	1 mm.	2 mm.
Wing rudiments, length	2·5 mm.	3 mm.
width	3 mm.	3·5 mm.

Seventh-stage Nymph.

These large hoppers are of a speckled greyish-green and brown colour marked with olive-green and brown patches. As in previous instars, there are conspicuous green markings mid-dorsally, particularly on the thorax. The prominent green eyes are longitudinally striped with white lines. The tegminal and wing rudiments are pale green with dark green markings on the latter, particularly at the base.

The antennae are composed of twenty-eight or thirty segments. The prominent keel of the pronotum (fig. 7) is deeply furrowed by three transverse grooves, the distal two of which stretch across the pronotum. The head, thorax, tegminal rudiments and legs are fairly heavily sclerotised. Both tegminal and wing rudiments are rather fleshy in appearance and extend to the fourth abdominal segment at the beginning of the instar, but when the abdomen increases in size with development they only reach to the third segment. The pronotum in this instar does not overhang the tegminal rudiments, only the distal parts of which are covered by the wing rudiments which, unlike their previous condition, do not meet in the mid-line.

The tips of the valves and the cerci of the older females are sclerotised and the tips of the spinules of the hind tibiae are likewise heavily sclerotised.

Measurements.

	♂	♀
Antennae	12 mm.	16 mm.
Body length	37 mm.	43–44 mm.
Hind femur	17 mm.	20 mm.
Tegminal rudiments, length	11 mm.	12·5 mm.
width	2 mm.	2·5 mm.
Wing rudiments, length	10 mm.	12 mm.
width	4 mm.	5 mm.

Duration of Instars and Number of Generations.

The number of nymphs dealt with was approximately 30.

There are seven nymphal stages, the details of the duration of which are tabulated on p. 329.

Instar	Limits of stage in days	Average	Occurrence
1st	10–17	13	December
2nd	10–14	12	
3rd	9–21	13	January
4th	12–26	19	
5th	14–19	—	February
6th	19–34	—	
7th	29–40	—	March

Total average duration, 134 days.

There is a single generation a year. The hoppers appearing after the first summer rains become adults in February and March. Adults were obtained in the laboratory in April and remained alive in the laboratory throughout the winter. The eggs deposited in April and May undergo a winter diapause and the hoppers emerge at the beginning of the next season.

Oedaleus nigrofasciatus (de Geer).

Uvarov (1929) noted the occurrence of *O. nigrofasciatus* in south-west Africa. Faure, who recorded (1932) the results of experiments on the effect of crowding of hoppers of this species, also described the colours of the nymphal instars. Key (1930) gave an account of the ecology and habits of *O. nigrofasciatus* in the Cape Peninsula and recorded that this species favours open spaces sparsely covered with the grass on which it feeds. The species exists in a number of colour varieties which merge into one another. The eggs are laid from January to June, but mainly in the months of March to May. The ground chosen for oviposition is firm and sometimes very hard, but egg-pods were also collected from coarse-grained, sandy soil. The nymphs emerge two or three months before the mature forms are found. The fully developed insects are found in the Cape from November to May. Key does not give details concerning the nymphal stages.

Nymphs of this species were found in the University grounds, Milner Park, Johannesburg, in grassy areas, in September. They vary in colour from brown and grey to fawn and green. They are active hoppers and are found together with hoppers of *Acrotylus angulatus*, *Acrida* sp., *Aiolopus thalassinus*, *Platypternodes brevipes*, *Pnorisa squalus* and *Catantops capicolus*. The adults which were found in the field from October onwards are good fliers and may be recognised by their yellow hind-wings. Both males and females are either green or brown in colour, with black stripes and markings. In flight they produce a stridulating noise. The males, in particular, stridulate vigorously. They were usually observed to copulate with females of the alternate colour. Copulation between males and females of the same colour was noted less frequently. Copulation and oviposition were observed in November, December, January and also in April in the field. The adults were observed to frequent open spaces devoid of bushes and grass, and the females selected such sites to oviposit in the hard soil.

A total of nineteen eggs was found in the ovaries of a female. The narrow egg-pod is fairly straight, measuring 29 mm. long by 5 mm. wide. The eggs, of which there are from 20–25, are arranged longitudinally in groups of four, and are enclosed in a thin layer of spongy tissue. At the lower end of the pod, the layer of tissue is thin and the eggs may be seen through it. At the upper end of

the pod there is a plug of spongy tissue. The measurements of the yellowish-white egg are 4–5 mm. by 1–1·5 mm. In the laboratory, nymphs began to emerge during the first week of January, from eggs laid during the last week of November, so that embryonic development takes about five weeks. They were fed on grass, lettuce, apricot leaves and apples, but showed a preference for the grass leaves.

First-stage Nymph (figs. 9 and 10).

Coloration and pattern.

The hoppers are light grey in colour with prominent black stripes laterally and white or straw-coloured bands medially. The antennae, composed of twelve segments, are comparatively long, being about half the length of the body. The thorax has an inflated appearance and consequently in side view seems to be somewhat arched dorsally.

The vertex and occiput are brown in colour with a narrow median white line. On each side of this brown area there is a white band extending from the posterior margin of the eye to the anterior margin of the prothorax. This stripe extends down the thorax and abdomen as a lateral white band which is constricted at the posterior portion of the pronotum and the mesothorax. On the abdomen the white band is sharply demarcated by narrow brown lines which are continuous with the longitudinal black stripe in the region of the thorax.

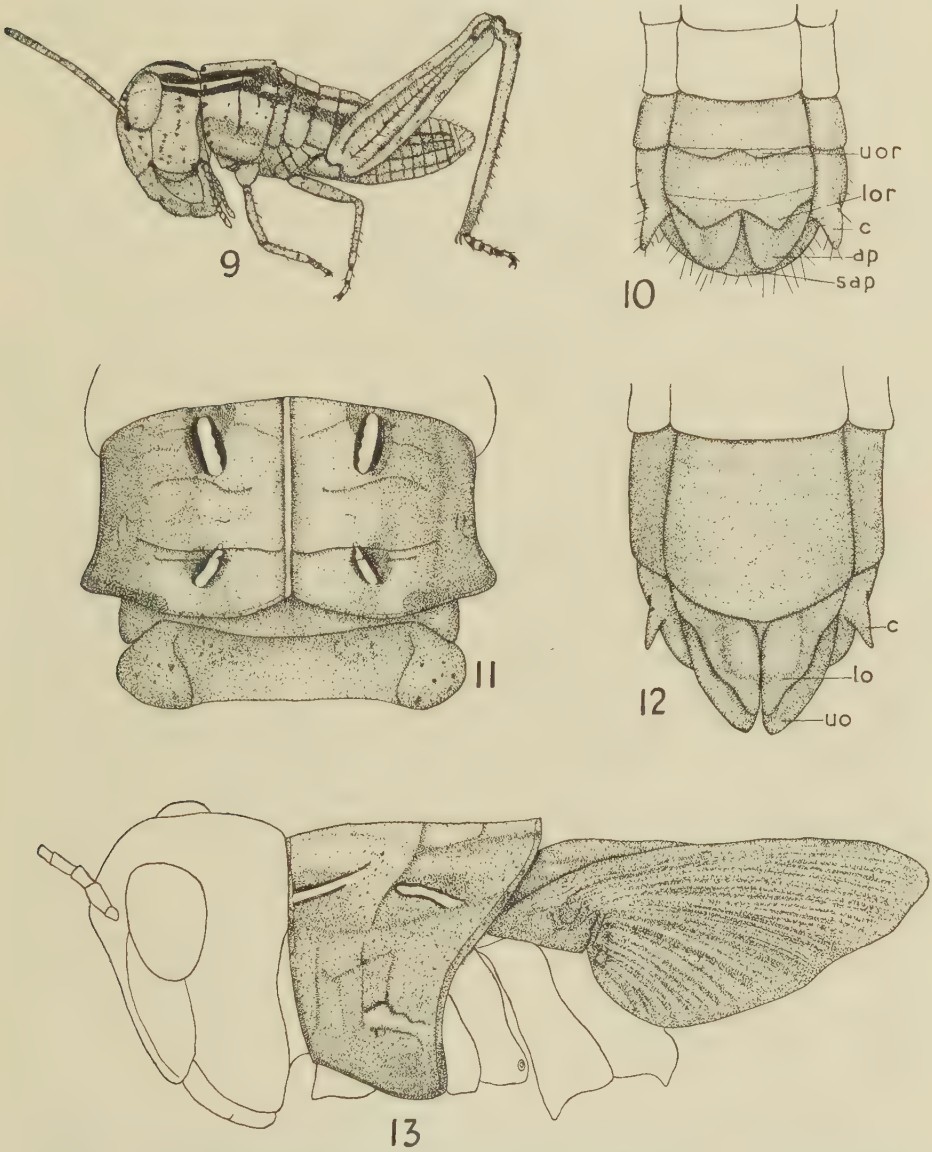
Next to, and ventral to, the white band on the head there is on each side a black stripe which extends down the length of the body to the end of the abdomen. This longitudinal black stripe is continuous with a similar dark brown band over the eye. The black band follows the dorsal curvature of the thorax and in the middle of the pronotum appears to be of a dark brown colour rather than black and its edges are not clearly defined. Towards the lower edge of the stripe there is a white line which continues to about the middle of the pronotum, where it is sharply inflected. On the posterior part of the pronotum there is a similar short white line which is sharply deflected.

Brown dots are distributed over the light grey face. On each side of the head there are three conspicuous fairly large black dots, one in front of the eye and one on each side of the upper margin of the mandible.

The filiform antennae are brown with a black distal clavate portion. The maxillary and labial palps are pale with five and three dark transverse circular bands respectively.

There are conspicuous transverse dark brown stripes on the first two pairs of legs. The hind legs are grey in colour with a black line down the middle of the outer surface. The proximal portion of the femur is of a lighter grey colour than the rest and the distal portion of the tibiae and the claws and onychium are black. The ventral surface of the abdomen is grey in colour.

Head. In profile the vertex slopes backwards and the face is directed obliquely downwards. The well-developed medial frontal ridges extend to the upper margin of the eyes which are placed dorso-laterally. The lateral frontal ridges are not so well developed and extend to the anterior margin of the eye. The antennae are composed of from fourteen to sixteen segments. *Thorax.* The anterior margin of the pronotum is straight, the posterior margin is curved and sharply incised in the mid-line. The straight mid-dorsal carina is well developed, but no lateral carinae are evident. The three transverse grooves are not very deeply furrowed. Black dots are regularly arranged at the margins of the pronotum. The lateral angles of the pronotum are rounded. The posterior



FIGS. 9–13.—*Oedaleus nigrofasciatus* (de Geer), nymphs. 9, first stage; 10, *ditto*, terminal abdominal segments; 11, third stage ♂, dorsal view of thorax; 12, fifth stage ♀, terminal abdominal segments; 13, fifth stage ♂. (For explanation of lettering see p. 318.)

margin extends slightly more laterally than the anterior, and the mid-dorsal length of the pronotum is slightly longer than its lateral margins. The mesonotum is overhung by the pronotum. The metanotum is longer than the mesonotum and the lateral margins of both are rounded and slightly extended. Cerci are developed at the end of the abdomen in both sexes, but rudiments of the external genitalia are only evident in the female (fig. 10).

Measurements.

Antennae	2·3–2·5 mm.
Body length	4·5–7 mm. (end of instar)
Hind femur	3 mm.

Second-stage Nymph.

The general appearance is similar to that of the first instar, but the colour of the hoppers varies from grey to fawn and brownish. The dark longitudinal band down the body is lighter in colour than previously and the humped appearance of the thorax is slightly more marked than in the previous instar.

Head. The head is darker in colour than the rest of the body and the area between the frontal ridges tends towards a deeper brown or grey shade. The antennae are composed of seventeen or eighteen segments, the slightly clavate extremity being now lost owing to the elongation of the segments. *Thorax.* The transverse grooves of the anterior portion of the pronotum are more evident laterally than dorsally. The anterior margin of the pronotum is straight as in the previous instar. The curved posterior margin is sharply incised in the mid-line. The posterior lateral angles are very rounded. The white stripes on each side are more marked on the thorax than on the head. On the lateral lobes of the pronotum there is a short white stripe sharply defined on a deep black ground. The pronotum overhangs the mesonotum which is shorter than the metanotum. The lateral margins of the meso- and metathorax are produced into light-coloured tegminal and wing rudiments. The transverse markings on the first two pairs of legs are not so marked as in the first instar. The hind femur as before has a dark line down the middle. The dorsal surface of the abdomen is light fawn in colour, outlined by a black line. The ventral surface is light in colour, the sides are darker. On each side of the first abdominal tergite a depressed area with a prominent stigma, surrounded by upraised thickenings, indicates the tympanal rudiment. The rudiments of the genitalia are developed in both sexes.

Measurements.

Antennae	2·5–3 mm.
Body length	7·5–8 mm.
Hind femur	4–4·5 mm.

Third-stage Nymph (fig. 11).

Coloration and pattern.

The nymphs are greyish-green or sometimes pale green in colour with grey or greenish-grey bands and cream-coloured stripes on the thorax. The longitudinal bands on the pronotum are not so clearly defined as previously and are in the nature of darkened areas. A cream or fawnish coloured band extends mid-dorsally from the meso- and metanota down the length of the abdomen and is sharply defined from the sides which are brown or brownish-grey in colour. The ventral surface of the abdomen is paler in colour than the sides. In general the patterns and markings are similar to those of the earlier instars. The terminal six segments of the antennae, which are composed of twenty-one or twenty-two segments, are conspicuous on account of their very dark colour. *Thorax.* The anterior margin of the pronotum is straight. The posterior margin is curved and incised medially as in the previous instar. The markings

on the pronotum are similar in arrangement to those of the second instar. The pale tegminal and wing rudiments are now better developed and are clearly differentiated from the rest of the meso- and metathorax. The tegminal rudiments are leaf-shaped. The wing rudiments are triangular and incipient veins are indicated.

The well-developed stigma and a circular area differentiated from the rest of the first abdominal tergite are the external indications of the tympanal organ. The valves of the ovipositors are well developed and separated from the genital plate and a close resemblance to the adult condition is becoming evident. The genital plate is differentiated in the male.

Measurements.

Antennae	3–3·5 mm.	
Body length	♂ 7–11 mm.	♀ 9–12 mm.
Hind femur	5–6 mm.	6–7 mm.

Fourth-stage Nymph.

Coloration and pattern.

Most of the males are brownish-grey in colour, while the females are brown or, less often, reddish-brown. The difference in size between the sexes is now evident, the females being larger. The bands on the head and pronotum are grey in colour, sometimes with pale green stripes. The black and white lines on the head and thorax are very marked. The wing rudiments are grey laterally and lighter coloured medially. On the darker-coloured portion of the wing rudiments there is a short diagonal white line outlined in black. The abdomen is grey or brownish-grey with a dorsal straw-coloured band, outlined in black. The markings and patterns are, on the whole, similar to those of the 3rd instar. The antennae are composed of from twenty-two to twenty-four segments. *Thorax.* The posterior margin of the pronotum is not sharply incised in the mid-line as in the previous instars. Laterally it is curved in an anterior direction, so that the postero-lateral angles are even more rounded than in the 3rd instar. The straight uninterrupted median carina is well developed, and as before the transverse grooves are more marked laterally than dorsally. The pale tegminal and wing rudiments are turned back on to the thorax and are directed postero-dorsally. The triangular wing rudiments, extending to the second abdominal segment, are attached along one-half the length of their base and they overlap the posterior part of the tegminal rudiments. Incipient veins are developed on the wing rudiments which do not meet in the mid-line. The elongate and narrow tegminal rudiments are attached at their outer margins and they, too, do not touch in the mid-line.

The tympanal organ now foreshadows the adult condition. The membrane, the border and the tympanal body can be discerned.

Measurements.

Antennae	5 mm.	
Body length	♂ 12–16 mm.	♀ 13·5–16·5 mm.
Hind femur	6–7·5 mm.	8·5 mm.
Tegminal rudiments, length	2·5 mm.	3·5 mm.
width	1 mm.	1 mm.
Wing rudiments, length	2 mm.	2 mm.
width	2 mm.	2 mm.

Fifth-stage Nymph (figs. 12 and 13).

Coloration and pattern.

The pattern and markings are, on the whole, similar to the previous instars. The ground colour of most of the males is grey or a mottled blackish or greenish-grey. A few males are pale green in colour. Some nymphs are very light, almost cream-coloured with mottled reddish-brown markings and stripes. The bands on the head and thorax are usually mottled greyish-black in colour, or sometimes greyish-green. The abdomen is grey, greyish-black or greyish-green in colour with a cream-coloured dorsal stripe. The ground colour of most of the females is leaf-green. In some nymphs there may be a greyish tinge to the green. A few nymphs are brownish-grey in colour with brown markings. The markings on the head and thorax of the green nymphs are mottled grey with either a black, brown or grey tinge and with cream-coloured and black stripes. The wing rudiments of the green nymphs are pale green in colour and greyish-green laterally; those of the brown specimens are light yellowish. There is a conspicuous, short, diagonal white bar outlined in black on the anterior lateral portion of each rudiment. The abdomen is usually mottled grey or brown in colour. As in previous instars, on the dorsal surface of the abdomen there is a characteristic cream-coloured, sharply defined band, which in some cases may be speckled with grey or green. The ventral surface of the green nymphs is pale green in colour. The antennae are composed of from twenty-four to twenty-eight segments, with the terminal segments slightly darker in colour. *Thorax.* Feebly developed lateral carinae may be discerned on the pronotum. The anterior margin of the pronotum curves forward in the mid-line. The posterior margin curves caudally and the pronotum is thus longer in the mid-line than laterally. The posterior lateral angle is rounded. The triangular wing rudiments are more erect and extend to the fourth abdominal segment or to the seventh segment in newly moulted specimens. They almost touch in the mid-line posteriorly and cover the tegminal rudiments except for the median portions. The lateral parts of the wing rudiments are dark, the median parts are lightly coloured. The elongate narrow tegminal rudiments, which also extend to the fourth abdominal segment, are also erect and meet in the mid-line. They are darkly coloured at their distal tips.

The tympanal organ is, to all appearances, in the adult condition. The transparent membrane is depressed and the stigma field is differentiated. The genitalia are fully developed but less sclerotised than in the adult (fig. 12).

Measurements.

Antennae	6 mm.	
Body length	♂ 13·5–17 mm.	♀ 16–23 mm.
Hind femur	9–9·5 mm.	10–10·5 mm.
Tegminal rudiments, length	7 mm.	7·5 mm.
width	1·5 mm.	1·5 mm.
Wing rudiments, length	6 mm.	6·5 mm.
width	3 mm.	3·5 mm.

Duration of Instars and Number of Generations.

There are five nymphal instars, the duration of which is tabulated below. A total number of approximately 120 nymphs was used for the observations.

Instar	Duration in days	Average duration in days
1st	8–10	9
2nd	11–22	15
3rd	14–23	17
4th	13–21 (30 in one case)	18
5th	14–31	21

Average total duration, 80 days.

It appears that, given favourable conditions, there may be two generations a year. The hoppers which hatch out in September after the first rains become adult in November and December and the eggs laid by them hatch out in January. These hoppers become adult in April and the eggs laid by them lie dormant in the soil during the winter, the young hoppers emerging after the first rains of the next season.

Aiolopus thalassinus (Fab.).

Although this is one of the common South African grasshoppers, very little concerning its biology has been recorded and, as far as I am aware, no description of the young forms has, as yet, been published.

Uvarov (1929) referred to a series of adult specimens collected from several localities in south-west Africa. Key (1930) gave a short account of the ecology and habits of *A. thalassinus* in the Cape Peninsula, and according to his observations it frequents open grassy areas from November to July.

This species was common in the University grounds from October to March and was found with *Oedaleus nigrofasciatus* and the other species noted previously (p. 313). Both hoppers and adults were collected in grassy localities, the straw colour and brown markings of the hoppers making them difficult to perceive on dry grass.

In certain localities on the north side of the grounds, near a creek with running water and where the grass was thick and green, the hoppers, although having markings identical with the straw-coloured forms found elsewhere, were of a bright green ground colour, which harmonised remarkably well with the grass. In the laboratory this green colour gradually disappeared with successive moults, so that in the final instar only a faint green tinge was apparent in some cases, while in others it had completely disappeared. After the final moult the young adults are of a pale straw colour, but within a few days their colour changes to dark grey.

Hoppers of the first and later instars were collected during September and October in the University grounds and reared to the adult stage in the laboratory, being fed chiefly on grass.

Oviposition was observed late in October, in December, January and March. According to Key (1930), oviposition takes place in the Cape Peninsula in April and May, firm but not hard ground being preferred. These differences in the times of egg-laying may be due to the seasonal differences between the Cape Peninsula and the Transvaal, or more probably the eggs were laid by females belonging to two different generations.

On many occasions in the laboratory numerous round small holes were observed in the soil at the bottom of the cage. On examination these were found to be well-excavated tunnels, in some instances reaching to, and leaving an impression on, the bottom of the drawer. Sometimes no egg-pods were

found in these holes, because the eggs had been laid on the surface of the soil and even on the sides of the cage. In the latter instance the soil was dry, but after moistening, egg-pods were found deposited in the soil. Apparently then the soil is first tested by the female, and if it is not moist enough the eggs are not deposited there. This fact was frequently noted in regard to oviposition in *Aiolopus*, to a lesser degree in *Trilophidia* and only occasionally or not at all in the other species.

The eggs are covered by a thin layer of spongy tissue. At the bottom of the egg-pod, which may be either curved or straight, the diagonally arranged eggs protrude through the thin spongy covering. The egg-pod is 24 to 29 mm. long and 4 to 5 mm. wide. It is narrower at the upper and lower ends, and particles of soil adhere to its covering. At the upper end of the pod there is a long narrow plug of spongy material. There are about twenty to twenty-five eggs in the pod, each measuring 3·5–4 mm. by 1 mm. The eggs are closely glued together and have a smooth chorion. They are fawn coloured when first laid but become darker in the soil. It appears that each female lays several egg-pods, for in a cage containing three females twelve egg-pods were obtained.

Description of Nymphal Instars.

First-stage Nymph (fig. 14).

Coloration and pattern.

Nymphs of the first instar are greyish-brown in colour with dark brown and grey markings. The head, and especially the mandibles and lower part of the face, are noticeably and characteristically very dark grey or almost black in colour. The palps are transversely banded. The hoppers fade to a uniform light brown colour when preserved. The antennae of the living specimens, which are brown with grey tips, are relatively short, clavate and composed of eleven segments. On each side of the head there are two characteristic dark brown dots marking the position of the anterior and posterior tentorial pits on the subgenal suture and lower post-occipital suture respectively. These dots appear in every subsequent instar and in the adult. The head in profile is slightly convex above, sloping forward, the face is strongly sloping, nearly straight and there is no prominent fastigium.

From the head and pronotum a continuous brown stripe extends on each side down the abdomen, the sides of which are dark grey in colour. Laterally there is a dark grey band on the thoracic segments. Along the anterior and posterior edges of the pronotum and the posterior edges of the meso- and metanota there are large regularly arranged dark dots.

The first two pairs of legs are brown, the distal joints being grey in colour. The hind legs are dark grey with transverse light stripes. There are dark transverse bands on the inside of the hind femur and dark spines on the hind tibiae, the distal joints of which are black.

The edges of the pronotum are curved. The pronotum is slightly raised into a median carina to which the two transverse grooves extend. The posterior margin of the pronotum is incised and curved. The lateral margins of the meso- and metathorax are slightly extended and curved. Cerci are developed.

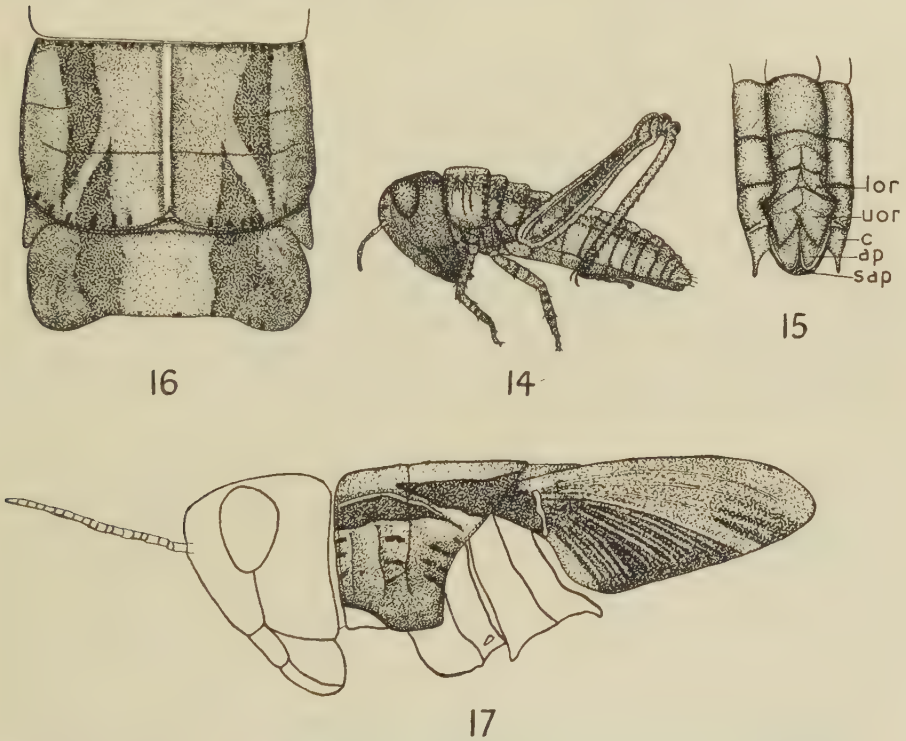
Measurements.

Antennae	0·7–0·8 mm.
Body length	4–5 mm.
Hind femur	1·5–2 mm.

Second-stage Nymph.

In general appearance this instar is similar to the first stage but the markings are more apparent than previously and the head is not so dark compared with the rest of the body. A prominent dark stripe extends from behind the eyes, along the thorax and abdomen, at the extremity of which it narrows. The antennae are composed of thirteen segments.

The relatively well-developed pronotum almost covers the mesonotum. The rounded, extended lateral edge of the metanotum forming the wing rudiment is paler and differentiated from the rest of the segment.



Figs. 14–17.—*Aiolopus thalassinus* (F.), nymphs. 14, first stage; 15, second stage ♀, ventral view of terminal abdominal segments; 16, third stage ♀, thorax; 17, fifth stage ♂. (For explanation of lettering see p. 318.)

The subgenital plate is differentiated into the rudiments of the valves of the ovipositor in the female (fig. 15).

Measurements.

Antennae	1 mm.
Body length	6·5 mm.
Hind femur	3 mm.

Third-stage Nymph (fig. 16).

In this instar the patterns and markings characteristic of the adults are evident. The antennae are composed of seventeen segments. A dark lateral band extending from behind the dark-coloured eyes is crossed by a pale band

in the distal half of the pronotum. The tegminal rudiments lie alongside the triangular wing rudiments (fig. 16). There are transverse dark bands and regularly arranged long brown dots on the hind femur.

The stigma on the first abdominal segment is relatively very well developed. Both valves of the ovipositors are developed in the female, and the subgenital plate of the male is differentiated.

Measurements.

Antennae	♂ 1·5 mm.	♀ 2 mm.
Body length	6–8 mm.	8·5–10 mm.
Hind femur	4–5 mm.	

Fourth-stage Nymph.

In this instar the patterns and markings are even more distinct than previously. The antennae are composed of twenty-one segments. The pronotum, the posterior edge of which is curved pronouncedly, is better developed than in previous instars. The triangular-pointed wing rudiments, which are turned backwards and upwards, extend to the first abdominal tergite but do not meet in the mid-line. The black markings extending from behind the eye along the thorax continue on to the wing rudiments, the longitudinal veins of which are discernible. A pale diagonal band extends across the base of the wing rudiments. The leaf-shaped tegminal rudiments extend to the first abdominal segment and are covered by the pronotum and wing rudiments.

The ridge surrounding the tympanal organ is differentiated and the rudiments of the tympanal bodies can be discerned.

Measurements.

Antennae	♂ 2·5 mm.	♀ 3·0–3·5 mm.
Body length	9·0–10·5 mm.	9·5–12·0 mm.
Hind femur	6·0 mm.	6·0–7·0 mm.
Tegminal rudiments, length	2·5 mm.	3 mm.
width	0·8 mm.	1 mm.
Wing rudiments, length	1·3 mm.	1·5 mm.
width	1·5 mm.	2 mm.

Fifth-stage Nymph (fig. 17).

In the final stage the broad dark brown or black and straw-coloured markings on the side of the head, thorax and wing rudiments, are conspicuous. In the green hoppers mentioned previously the hoppers are a mottled grey on a green ground colour. The females are noticeably bulkier than the males. The antennae are composed of twenty-two or twenty-three segments in the male and from twenty-three to twenty-five segments in the female.

The wing rudiments extend to the fifth abdominal segment. The external genitalia and the tympanum are almost in the adult condition.

Measurements.

Antennae	4 mm.	
Body length	♂ 12–16 mm.	♀ 15–20 mm.
Hind femur	6·5–8·5 mm.	8·0–9·0 mm.
Tegminal rudiments, length	5 mm.	6·5 mm.
width	1·3 mm.	1·5 mm.
Wing rudiments, length	4·5 mm.	6 mm.
width	2·3 mm.	3 mm.

Duration of Instars and Number of Generations.

Observations were made on approximately 60 nymphs. There are five nymphal instars the durations of which are summarised below :—

Instar	Duration in days
1st	8
2nd	9
3rd	11
4th	16
5th	15–24

Total duration, 64 days.

It appears that, as in other smaller species discussed, viz. *Trilophidia conturbata* and *Oedaleus nigrofasciatus* and *Acrotylus angulatus*, there may be two generations a year if conditions are favourable. The hoppers emerging early in the season become adult in October and deposit eggs from late in October to January. The hoppers developed from these eggs become adult in about two or three months and the eggs laid by them in March and April undergo a winter diapause in the soil and give rise to the new generation of the next season.

Trilophidia conturbata (Walk.).

As far as I am aware, no previous description of the nymphs of this species has been published. A few older nymphs and adults of this species were found in the field early in the first week of September 1935, before the rains of the season had commenced. After the first rains numerous young nymphs were observed in the field.

The colourings and markings of the grasshoppers harmonise very well with the reddish-brown soil of their environment. The adults which were afterwards reared in the laboratory were greyish in colour compared with the reddish-brown grasshoppers found in the field. They are geophilous, and both adults and nymphs were most abundant where patches of open soil were interspersed with vegetation. Besides grass, lettuce and apples, these grasshoppers ate apricot and oak leaves, but showed a preference for grass.

Copulation of the adults found in September was observed in the first week of October and egg-pods were deposited a week later. Except for the lower portion, which is slightly bent, the egg-pods are fairly straight, and are about 20–23 mm. long and 3 mm. wide. Particles of soil are found adhering to the walls of the pod. The upper half of the pod is composed of a plug of spongy material. In the lower portion the eggs are found clustered longitudinally and are closely glued together by a thin layer of spongy tissue. The spongy layer forming the wall of the pod is very thin, and at the lower end is so thin that the eggs may be in contact with the soil. There are about seventeen eggs in a pod. The chorion of the eggs, which measure 4 mm. by 1–1·2 mm., is thin and yellowish coloured and comes off in flakes. The embryonic period varied from 23 to 31 days, after which time the nymphs appeared. When they first emerge, the nymphs are light brown in colour but within a short time their colour darkens to mottled grey.

First-stage Nymph (fig. 18).

Coloration and pattern.

Nymphs of the first instar are mottled grey in colour with black stripes and markings. Preserved hoppers are greyish-brown in colour. Fine black hairs are distributed all over the body. A distinguishing feature is the dark coloration of the posterior two-thirds of the femur, the tibia and the tarsus, with a narrow light, transverse band on the femur and with the last tarsal segment and claws of a much paler colour. *Head.* The head is grey in colour, and mid-dorsally on the occiput is a pair of narrow dark bands extending from behind the eye to the anterior margin of the pronotum and continuing for a short distance on to the pronotum. The frons is oblique in profile and the distal margin is slightly deflected ventrally. There are well-marked frontal ridges in front of and behind the antennae. The frontal ridge is dilated at the lateral ocellus. The vertex is sloping and the large eyes, which are greyish with a reddish-brown rim, are placed laterally. The clypeus and labrum are the same colour as the frons, but the maxillary and labial palps are paler with three to five dark transverse bands arranged at regular intervals. The antennae are antero-ventral in position and are composed of about seven segments and a distal clavate portion. The two basal segments and the clavate tip are dark in colour, the intervening segments are yellowish-white in colour, with dark circular thickenings at their distal margins, on which fairly long dark hairs and dots are regularly arranged. *Thorax.* There are two transverse furrows and a slight median keel on the fairly well-developed pronotum. The posterior margin, which is straight, is about the same length as the anterior margin, which curves forward slightly to the mid-line and is directed posteriorly at its lateral margins. Small black dots are distributed over the pronotum, particularly at the anterior and posterior margins. The meso- and metathorax are lightly mottled grey in colour with straight posterior and rounded lateral margins. The first two pairs of legs are grey in colour with transverse dark brown bands along their whole length. On both their outer and inner surfaces the well-developed hind legs are black except for two grey areas on the femur and the last tarsal segment. The one grey area on the femur is found proximally and the other is a very prominent transverse band half-way between the distal and proximal ends of the femur. The tibia and the spines are black, but the claws and the last tarsal segment are white and are in sharp contrast with the rest of the leg. The dorsal and ventral surfaces of the abdomen are grey in colour, the sides are darker. At the end of the abdomen a pair of cerci is developed, but the genital plates are not, as yet, differentiated.

Measurements.

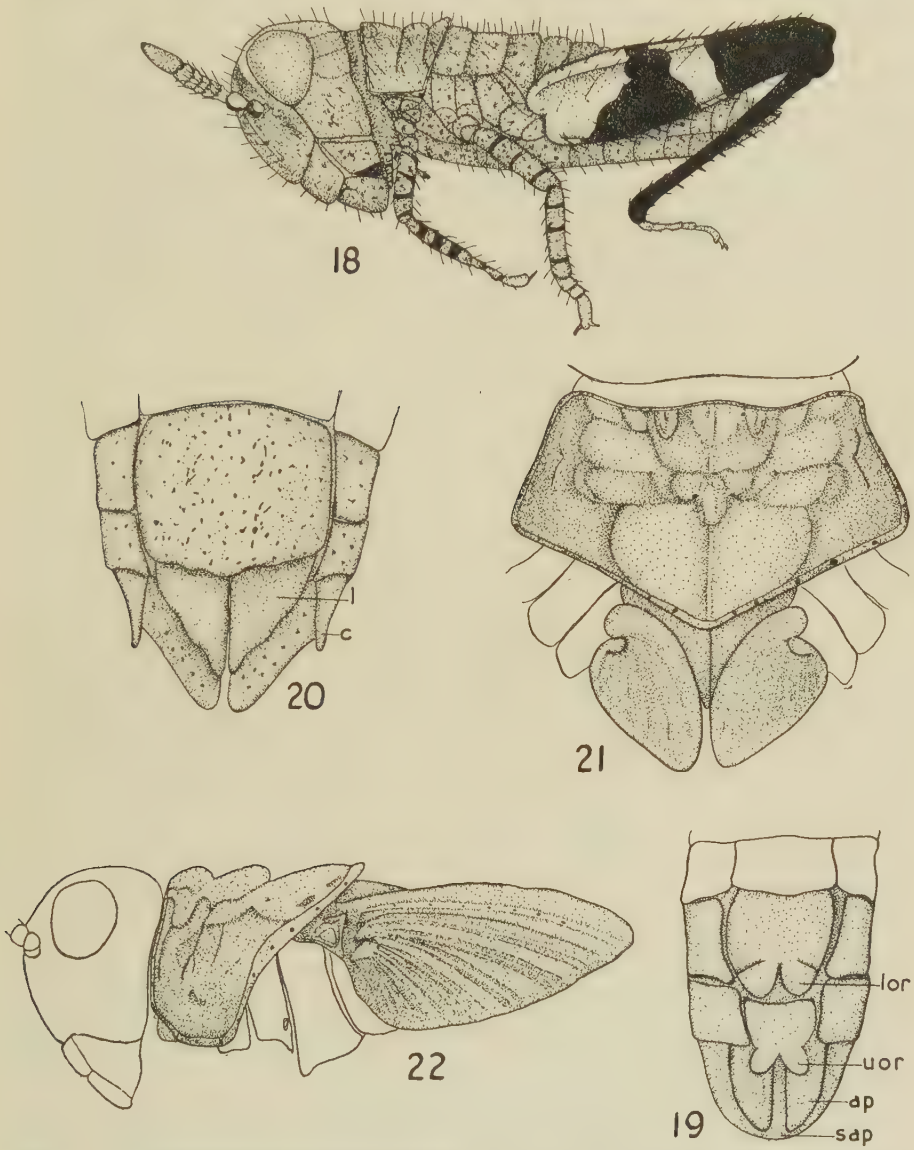
Antennae	1 mm.
Body length . . .	2·8–4 mm.
Hind femur . . .	2·3–2·5 mm.

Second-stage Nymph.

Coloration and pattern.

The general appearance, pattern and markings are, on the whole, similar to those of the previous instar, but the colour has changed from mottled grey with black for the hind legs to a light mottled brown colour for the body with darker brown bands on the hind legs but it is still possible to distinguish the lighter transverse band on the hind femur. The tibia and tarsus with the exception of

the last tarsal segment and the claws may be of a very dark brown colour. After the moult the nymphs are very pale but they darken in a few days. The hairs



FIGS. 18–22.—*Trilophidia conturbata* (Walker), nymphs. 18, first stage; 19, second stage ♀, ventral view of terminal abdominal segments; 20, fifth stage ♀, *ditto*; 21, fourth stage ♂, dorsal view of thorax; 22, fifth stage ♂. (For explanation of lettering see p. 318.)

distributed over the body are less numerous than in the previous instar and there are light brown markings on the face.

The antennae are composed of eight segments in addition to the distal clavate portion. The antennae are still pale in colour and only slightly darker than in

the previous instar. *Thorax.* The well-developed mid-dorsal keel on the pronotum is deeply furrowed by the transverse grooves. The lateral keels are more feebly developed. The middle part of the anterior portion of the pronotum is a darker brown in colour than the rest. At the lateral lobes of the pronotum there are also dark brown areas. Along the posterior margin of the pronotum there is a narrow lighter coloured band. Black dots are distributed over the pronotum. The mesonotum is slightly better developed than the metanotum and the tegminal and wing rudiments are indicated by the rounded slightly extended, lateral margins of the meso- and metanotum respectively. The patterns and markings of the legs are similar to those of the previous instar, but the contrast between the light and dark coloured areas is slightly less marked than in the previous instar. The ventral and lateral surfaces of the abdomen are of a darker brown colour than the dorsal surface. The subgenital plate of the male and the valves of the ovipositors of the female (fig. 19) are now evident.

Measurements.

Antennae	1·3 mm.
Body length . . .	3·5–4·8 mm.
Hind femur . . .	2·8–3 mm.

Third-stage Nymph.

Coloration and pattern.

The light and dark brown coloration of the third-stage hopper is the same as in the second instar. The head is somewhat lighter in colour than the rest of the body. There are light brown or fawnish-coloured markings on the face. The contrast between the light and dark coloured areas on the hind legs is not so marked as in the earlier instars, but the last tarsal segment and the claws are still sharply contrasted by their paler colour. Proximal to the two dark brown areas on the hind femur there is a third diffuse dark area and the inner surface of the proximal half is very darkly coloured. The antennae are now almost concolorous with the rest of the body. They consist of nine segments in addition to the distal portion which is rather darker in colour than the rest of the light brown antenna, on which narrow transverse white stripes are regularly arranged. *Thorax.* The well-developed pronotum overhangs and almost completely covers the mesonotum and, as in previous instars, it is produced in the dorsal mid-line into three almost equidistant backwardly directed ridges, by the presence of two transverse grooves. There are dark brown areas in the median anterior portion and the lateral lobes, and the posterior margin forms a pale band interrupted by dark dots at the bases of the dark setae. The pronotum is longer in the mid-line than laterally. The lateral portions of the meso- and the metanotum are produced into tegminal and wing rudiments, which are paler than the meso- and metanotum. Traces of veins can be distinguished on both wing and tegminal rudiments. The genitalia are further developed than in the earlier instars.

Measurements.

Antennae	2·3 mm.	
Body length	♂ 5–6 mm.	♀ 5·5–7 mm.
Hind femur	3·5 mm.	4–4·5 mm.

Fourth-stage Nymph (fig. 20).

Coloration and pattern.

The coloration is, on the whole, slightly darker than that of the previous instar. There are narrow white transverse bands on the brown antennae. The light brown or fawnish-coloured markings on the face are not so sharply marked as in the previous instar. There is a yellowish-white band interrupted by brown dots along the posterior margin of the pronotum, and median and lateral dark brown areas which are not so obvious as in the previous instar. The dark and light brown areas are more sharply contrasted on the inner surface of the femur than on the outer. The hind tibiae are darkly coloured only in their distal portions, and the whole of the tarsus and the claws are light in colour. The spines are also light coloured with black tips. The antennae are composed of eleven to thirteen segments and a distal clavate portion, which is of a deeper brown colour. *Thorax.* The transverse grooves on the pronotum are well marked. The angle at the mid-line of the posterior margin is more acute than in previous instars, the posterior margin sloping sharply in a forward direction. The tegminal and wing rudiments are well developed and vertical in position. The brown wing rudiments are roughly triangular in shape, and they almost touch in the mid-line. The upper portions are lighter coloured and the rudiments of the veins, on which black hairs are regularly arranged, are discernible. Except for the portion in the mid-line the tegminal rudiments are entirely covered by the wing rudiments which extend to the anterior margin of the second abdominal segment. The tegminal rudiments are leaf-shaped and are lightly coloured with longitudinal dark bands.

Measurements.

Antennae	2·5 mm.	
Body length	♂ 7–9·5 mm.	♀ 8–10·5 mm.
Hind femur	4·5 mm.	6 mm.
Tegminal rudiments, length	2 mm.	
width	0·5 mm.	
Wing rudiments, length	1·5 mm.	
width	1·5 mm.	

Fifth-stage Nymph (figs. 21 and 22).

Coloration and pattern.

The patterns and markings are similar to the previous instar. The ground colour is a dark mottled brown. A light coloured band found along the posterior margin of the pronotum appears to be more marked in the younger nymphs of the instar, and unlike the previous instars it is not interrupted by dark brown markings. The dark brown markings on the hind femur are not so sharply contrasted as in earlier instars and are most obvious on the dorsal ridge of the femur. On the inner surface of the hind femur there is a dark brown area extending for rather more than the proximal half, and a short distance behind this are two dark brown areas, arranged longitudinally and separated by a median ridge. There are two very obvious transverse light fawnish-coloured stripes on the hind tibiae, the rest of which is shiny black. *Head.* The eyes are now very prominent. They bulge out laterally from the head, and are of the same speckled fawn and brown colours as the body, with a slightly darker rim. The antennae are composed of sixteen to eighteen segments plus the distal tip,

which as in previous instars is somewhat darker than the rest of the antenna. There are no obvious colour contrasts on the antennae, but there is a ring of setae at the distal margin of each segment. *Thorax.* The well-marked median keel, which appears to be less marked in the posterior half of the pronotum than in the anterior part, is deeply cleft by the transverse grooves. The lateral keels are not so well developed as the median. They are depressed by the transverse grooves and diverge posteriorly. The well-developed triangular wing rudiments extend to the seventh abdominal segment of newly moulted nymphs; in older nymphs they extend only to the fifth abdominal segment. They are attached at the inner basal angle and their apices are directed postero-dorsally and almost touch in the mid-line. The longitudinally arranged veins show distinctly. The long, narrow tegminal rudiments extend as far back as the wing rudiments which cover them for their entire length. The tegminal rudiments are almost white in colour with a longitudinal dark brown band, whereas in the adult there are two light transverse bands breaking up the darker brown general ground colour of the tegmina into three areas. Longitudinal thickenings are discernible in the tegmina. The rudiments are attached at their outer margin and in the mid-line they are in contact. The genital rudiments in both sexes are well developed and resemble the adult condition (fig. 22). The thin transparent membrane and the thickened border of the tympanal organ are well developed.

Measurements.

The difference in the sizes of the two sexes is now more apparent.

Antennae		3·5–3·8 mm.	
Body length		♂ 10·5–11 mm.	♀ 12–12·5 mm.
Hind femur		5·5–6 mm.	7 mm.
Tegminal rudiments,	length	4 mm.	4 mm.
	width	1 mm.	1 mm.
Wing rudiments,	length	4·5 mm.	5 mm.
	width	3 mm.	3 mm.

Duration of Instars and Number of Generations.

The results are based on observations made on a total of 45 hoppers. There are five nymphal instars. It is probable that in the field the duration of the instars may be less than recorded in the laboratory. The duration of the instars may be tabulated as follows :—

Instar	Duration in days	Average duration in days
1st	18–28	22
2nd	13–22	17
3rd	11–24	17
4th	18–25 (40 in one case)	21
5th	15–30 (at least 37 in one case)	23

There are two generations a year. The nymphs which hatch out after the first rains reach the adult stage and oviposit in December. The eggs hatch in about three weeks, and the grasshoppers become adult and oviposit in the late

summer or autumn. The eggs hatch out the next summer after the first rains. Some grasshoppers appear to live through the winter in the late nymph or adult stage and oviposit in September or early in October.

Acrotylus angulatus Stål.

These geophilous grasshoppers, with their light brown colouring and dark brownish stripes and markings, closely resemble the soil on which they are found and were collected in the University grounds, Milner Park, Johannesburg. They occur together with the other small species of Acrididae mentioned on page 313. When disturbed, the adults of this species, like those of *A. insubricus* (Scop.) (Uvarov, 1928), were observed both in the field and in the laboratory to exhibit the peculiar habit of burying themselves in the sand, apparently as a defensive measure. This behaviour was never observed in any of the other species.

Nymphs were found in August and September. The grasshoppers were fed on grass, lettuce, apricot leaves and apples, but showed most preference for grass. The season of the adults extended from October to March. Copulation was observed late in September, in October and November, oviposition occurring during November and December.

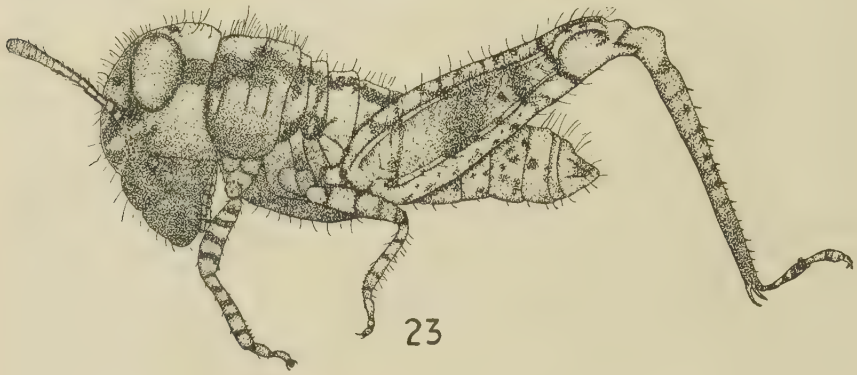
The egg-pod, measuring 25 mm. by 4 mm., is straight and fairly narrow. The eggs are enclosed in a layer of spongy tissue to which soil adheres and these agglutinated sand particles form the wall of the egg-pod. Unlike *A. crassus* Sauss. (Key, 1930), the upper end of the egg-pod consists of a narrow plug of spongy material. In each pod there are about twenty yellow eggs measuring 3·5 mm. by 1·5 mm., and towards the end of the embryonic stage the grey head and brown eyes of the developing embryo may be seen through the thin chorion. More than one egg-pod may be laid by each female. Nymphs emerged late in November and during December and January so that embryonic life lasted for about three weeks or more. On examination of the soil it was found that some larvae had emerged from the egg-pod but for some unknown reason had failed to reach the surface.

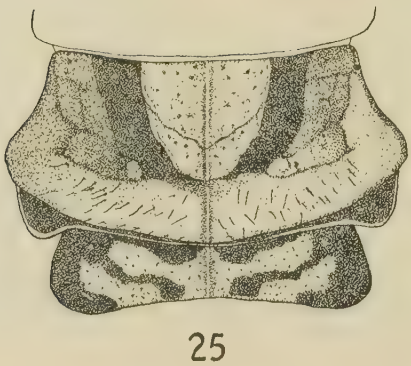
First-stage Nymph (fig. 23).

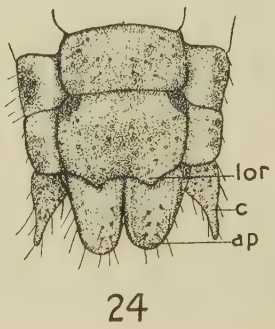
Coloration and pattern.

The ground colour is a dark brown with black stripes and markings. The brown colour fades in preserved specimens and the markings are consequently more obvious than in the living nymphs. On each side of the head, a broad black stripe extends from behind the fairly prominent brownish-grey eyes, between the gena and occiput to the anterior margin of the prothorax. On the thorax these bands converge towards each other and are continued as broad markings along the sides of the abdomen. There are four characteristic black markings on the dorsal and inner surface of the light brown hind femur. Numerous fine black hairs are distributed all over the body. In profile the head is convex above and slopes forward to the strongly curved face. The median frontal ridges are well developed The clypeus, labrum, mandibles and lower part of the frons are black, the genae are reddish or almost tangerine-coloured. The vertex and upper part of the frons are brown, mottled with black patches and the occiput is brownish-grey in colour. The maxillary and labial palps are white with transverse black bands. The antero-ventrally placed and somewhat clavate antennae are composed of thirteen or fourteen segments. The two basal segments are black while the distal clavate portion, comprised of six segments, is

brownish. The segments between the base and free extremity are almost white with longitudinal lateral brown stripes. *Thorax.* On each side of the pronotum there is a broad black stripe continuous anteriorly with the stripe on the head







FIGS. 23–26.—*Acrotylus angulatus* Stål, nymphs. 23, first stage; 24, *ditto*, ventral view of terminal abdominal segments; 25, third stage, dorsal view of thorax; 26, fifth stage ♀. (For explanation of lettering see p. 318.)

and posteriorly with the meso- and metathorax and abdomen. On the pronotum the stripes converge towards each other posteriorly. There is a slight median carina, but lateral carinae are not developed. The transverse grooves are fairly well marked. The anterior margin of the pronotum is straight and it

is longer in the mid-line than at the sides. The lateral angles of the pronotum are rounded, The pronotum overhangs and almost covers the mesonotum. The mesonotum and metanotum are comparatively short with black rounded lobes laterally. The first two pairs of legs are fawnish coloured with transverse circular dark bands arranged at regular intervals. Proximally these bands are brown in colour, distally they are black and the claws are also black. The hind femur is brown with characteristic black markings along its dorsal edge, three of those in the distal two-thirds of the hind femur being fairly conspicuous. The markings are continuous dark transverse bands on the inner surface. Except for the portion near the femoro-tibial joint, which is grey, the hind tibiae are black. The spines and claws are black and the tarsal segments are grey with black stripes. The dorsal surface of the abdomen is brown, the ventral is greyish and laterally there are black markings. Cerci are developed and the rudiments of the valves of the ovipositor are indicated by the divided lobes of the genital plate (fig. 24). The rudiment of the tympanal organ may be discerned as a depression surrounded by a slight semicircular ridge.

Measurements.

Antennae	1·3 mm.
Body length	4·3–5·5 mm. (end of the instar)
Hind femur	2·3–2·5 mm.

Second-stage Nymph.

Coloration and pattern.

The general pattern and markings are similar to the previous instar but the ground colour of the nymphs is of a lighter brown. There is a reddish-brown tinge over the body which is most noticeable on the frons. The antennae are composed of sixteen or seventeen segments and the distal extremity is not so markedly clavate as in the first instar. The antennae are light grey in colour with darker grey along the edges. *Thorax.* The dark brown bands extending on each side from the frontal sutures, across the grey eyes and converging on the thorax, terminate sharply at a light-coloured circular marking on the posterior third of the pronotum. There are median light brown areas on the otherwise black meso- and metathorax, the lateral edges of which are rounded. The legs are light brown in colour with circular contrasting stripes which are dark brown proximally and black distally. The dark brown markings on the brown hind legs are not so conspicuous as in the previous instar. The hind tibiae are grey proximally and black distally. The abdomen is reddish-brown in colour dorsally and grey ventrally, with dark brown markings on each sternite. Along the sides of the abdomen there are conspicuous black areas on the third, fourth and seventh segments. The tympanal area with the comparatively large stigma is differentiated from the rest of the first abdominal tergite. The division of the lobes of the genital plate forming the rudiments of the ovipositors is further developed.

Measurements.

Antennae	1·5 mm.
Body length	5·5–7 mm.
Hind femur	3·0–3·5 mm.

Third-stage Nymph (fig. 25).

In this instar a difference in size between the males and females is apparent. These nymphs are a slightly paler brown than those of the previous stages and the black markings and patterns which are, on the whole, similar in arrangement to those of the previous instar are more conspicuous and defined. The head, thorax and legs are lighter in colour than the abdomen. The vertex and occiput are brown with a salmon-coloured tinge; the genae are grey. The lower part of the frons is dark brown almost black and this dark band extends on each side across the lower part of the eye on to the pronotum where it terminates at a light fawn coloured spot on the posterior third of the pronotum (fig. 25). The tips of the antennae, which are composed of eighteen or nineteen segments, are dark brown and the remaining portions are light brown with transverse white stripes.

The median carina of the pronotum, which has a distinct reddish tinge, is slightly raised above the general surface. The lateral margins are less rounded than previously and the pronotum covers the greater part of the mesonotum. The narrow, almost black tegminal rudiments extend on each side to about the middle of the broader triangular wing rudiments, which are also of a blackish colour and which are separated from the rest of the metanotum by a depression.

The ventral surface of the abdomen is light brown with a darker area on each sternite. The dorsal surface is dark brown with characteristic black markings laterally.

The tympanal area and stigma are clearly defined within a semicircular depression on each side of the first abdominal tergite. The cerci, genital plate of the male, and the ovipositor valves of the female are evident.

Measurements.

Antennae . .	2–2·5 mm.
Body length . .	♂ 6·5–8·5 mm. ♀ 8 mm. at beginning to 10 mm. at end of the instar.
Hind femur . .	5·5 mm.

Fourth-stage Nymph.

In this instar the characteristic features of the adult coloration and pattern are evident. The thorax, tegminal and wing rudiments and hind femora show a marked increase in development on the previous instars. The contrast between the pale and dark markings is rather more evident than previously. The antennae, composed of twenty or twenty-one segments, are light brown in colour with transverse grey bands and conspicuous dark grey extremities. The labrum and clypeus, as before, are black. The converging dark brown bands, extending on to the pronotum from the frons, are defined on their upper margin by a thin yellowish line which corresponds with the slightly developed lateral carinae. On each side there is a dark brown area near the lateral margin of the pronotum. The posterior third is in marked contrast with the rest of the pronotum, being yellowish or light greyish in colour. The shape of the pronotum is more like that of the adult than in previous instars. In side view the posterior margin slopes sharply forward from the mid-line.

The triangular wing-rudiments extending to the first abdominal segment are turned back postero-dorsally on to the abdomen and almost touch in the mid-

line. The lower half is dark brown or grey in colour, the upper portion of each wing rudiment is light brown or yellowish. About midway on the rudiments there is a short conspicuous white bar outlined in black. Only the posterior portions of the dark tegminal rudiments are covered by the wing rudiments.

The light brown colour of the well-developed hind femora is in sharp contrast with the darker brown of the abdomen. The tympanal membrane is differentiated and in the female the valves of the ovipositors are almost fully developed. As in previous instars numerous fine hairs are distributed over the body.

Measurements.

Antennae	3 mm.	
Body length	♂ 8·0–10 mm.	♀ 9·5–12·5 mm.
Hind femur	6·0 mm	6·5 mm.
Tegminal rudiments, length	1·8 mm.	2 mm.
width	0·5 mm.	0·8 mm.
Wing rudiments, length	1·3 mm.	1·5 mm.
width	1·5 mm.	1·8 mm.

Fifth-stage Nymph (fig. 26).

Young hoppers of this stage are a pale yellow at first but within a day or two their colour darkens to brown or grey. All the characteristic features of the adult coloration and pattern are evident and there is a marked difference in the size of the males and females. There is a sharp contrast between the brown ground colour, the dark brown stripes and markings and the light yellow spots and bands. The antennae, although composed of the same number of segments as those of the previous instar, are slightly longer. They are darkest at their free extremity, which is not clavate as it was in the earlier instars.

On each side of the pronotum there are two conspicuous yellow markings or spots connected with the longitudinal dark brown bands. A similar marking occurs on the wing rudiments, the upper yellowish part of which contrasts with the lower grey or brown portion. Rudimentary veins are apparent on the wing rudiments which extend to the fourth abdominal segment. There are longitudinal dark bands on the narrow tegminal rudiments, which also reach the fourth abdominal segment and which are covered by the wing rudiments.

There are three conspicuous dark brown triangular markings on the light brown well-developed hind femur. The dark bands on the inner surface of the femur are not so sharply defined as in previous instars. The distal portion of the otherwise pale hind tibiae is black. There are transverse dark brown markings, particularly on the third and fourth abdominal segments. The tympanal organ and external genitalia are practically in the adult condition.

Measurements.

Antennae	♂ 4·0 mm.	♀ 4·5 mm.
Body length	10 mm.	13·5 mm.
Hind femur	6·5 mm.	8·0 mm.
Tegminal rudiments, length	5 mm.	6 mm.
width	1 mm.	1 mm.
Wing rudiments, length	4 mm.	5 mm.
width	2 mm.	2·5 mm.

Duration of Instars and Number of Generations.

Forty-five nymphs were used for the observations. The duration of the five instars may be summarised as follows :—

Instar	Duration in days	Average duration in days
1st	12–20	16
2nd	16–23	19
3rd	9–21 (36 in one case)	16
4th	12–18	15
5th	15–27	21

Total average duration, 87 days.

During August and September nymphs emerged from eggs which had been deposited towards the end of the previous season. These nymphs became adult in about two or three months and copulation and oviposition were observed from October to December. About a month after oviposition hoppers emerged from the eggs and, in their turn, these hoppers became adult in about two or three months. It seems likely, therefore, that there are two generations a year. A few older hoppers and adults, however, live through the winter until the next season.

Zonocerus elegans (Thunb.).

During the course of the investigation on the above, egg-pods and hoppers of *Zonocerus elegans* (Thunb.) were also obtained and measurements of the instars and the duration of the nymphal stages were recorded. Van der Merwe and Kent (1925) have described the food-plants, distribution, life history and habits

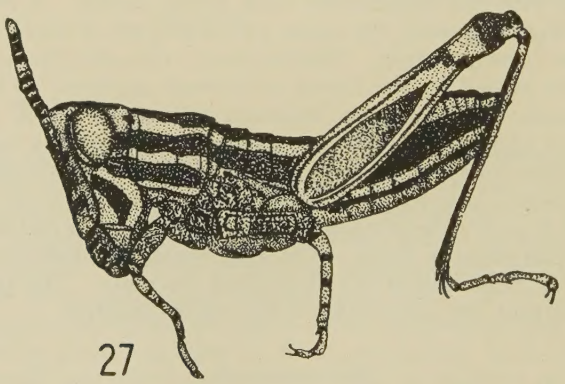


Fig. 27.—*Zonocerus elegans* (Thunb.), first stage nymph.

of *Z. elegans*, in addition to results of experiments with poison baits on this grasshopper which is a pest of orchards, vegetable and flower gardens. The first instar (fig. 27) is described by them in detail and the time taken to reach the adult stage is recorded as from 84 to 96 days in cages and from 73 to 78 days in the field. The actual number of instars and the duration of each was, however,

not recorded. In view of these facts, a tabular summary of the life history of *Z. elegans* is furnished below.

Summary of Life-cycle of Zonocerus elegans *(Thunb.) (Brachypterous form).*

Nymphal instar	Measurements in mm.			Antennal segments	Tegminal rudiments	Wing rudiments	Duration in days
	Antennae	Body length	Hind femur				
1st . .	2	6–7·5	3	8	Lateral margins slightly rounded.		26 days
2nd . .	3·5	8–13	5	13	Slight lateral lobes of meso- and metanotum differentiated.		16 days
3rd . .	5–6	13·5–17	6·5–7·5	15 or 16	Distal portion protrudes from under pronotum.	Extend backwards to 1st abdominal segment.	19 days
4th . .	8	17–22	10	17 or 18	Yellow and black, pointed, extend to metathorax.	Black, yellow margin, triangular, turned back on abdomen to 1st abdominal segment.	18 days
5th . .	12	23·5–30	14	17 or 18	Extend to 2nd abdominal segment. Slightly shorter than wing rudiments.	Extend to 2nd abdominal segment. Length 4 mm.	23 days
Adult ♂ .	11·5	28–36	12	17 or 18	5·9 mm. long. Cover 2 abdominal segments.	Narrow, reduced. Extend to 1st abdominal segment.	December to May
♀ .	14	35–50	16·5	17 or 18	10–12 mm. long.	Ditto.	

From the above it is evident that the complete cycle took about 102 days in the laboratory, being a slightly longer duration than that recorded by van der Merwe and Kent (1925).

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